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The cognitive antecedents and motivational consequences of the feeling of being in the zone

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ABSTRACT

The feeling of being in the zone (related to "flow") is marked by an elevated yet effortless sense of concentration. Prior research suggests that feelings of being in the zone are strongest when the demand posed by a task matches one's level of ability (i.e., the balance hypothesis). In the present article, we tested this hypothesis using a novel experimental paradigm. By collecting numerous zone judgments for each participant, we were able to examine intra-individual sources of variance that explain why people often feel more or less in-the-zone on the same task from one moment to the next. The results of two experiments provide support for what we have termed the balance-plus hypothesis, which posits that zone experiences are strongest (Experiments 1–2) and have the greatest motivational force (Experiment 2) when the balance between task demand and ability is accompanied by positive assessments of one's own performance.

1. Introduction

The feeling of being 'in-the-zone' is experienced across a broad range of cultures and activities (Jackson, 2000; Massimini & Carli, 1988; Moneta, 2004). It is evident not only when a jazz musician improvises a solo or a basketball player takes a jump shot, but also when a person plays a computer game. Qualitative research has established that feeling in the zone is marked by a heightened level of absorption and concentration that feels productive yet effortless (Csikszentmihalyi, 2000; Moneta & Csikszentmihalyi, 1996). Although this feeling has been identified as a phenomenologically unique psychological state in domains as disparate as sports (Cooper, 1998; Garfield & Bennett, 1984; Loehr, 1986; Ravizza, 2007), art (Csikszentmihalyi, 2000; Dewey, 1934) and human–computer interaction (Konradt, Filip, & Hoffmann, 2003; Novak, Hoffman, & Duhachek, 2003), it has only been investigated experimentally by several research groups in a small number of published studies (Engeser & Rheinberg, 2008; Keller & Bless, 2008; Keller, Bless, Blomann, & Kleinböhl, 2011; Keller & Blomann, 2008; Mannell & Bradley, 1986; Rheinberg & Vollmeyer, 2003; Schiefele & Raabe, 2011; Schiefele & Roussakis, 2006; Ulrich, Keller, Hoenig, Waller, & Grön, 2014). The present experiments attempt to address this gap in the literature by exploring the cognitive antecedents and motivational consequences of the feeling of being in the zone.

The feeling of being in the zone is similar to being in a state of flow, which has been described as an enjoyable feeling of deep absorption in a task (Csikszentmihalyi, 2000). Flow is thought to occur during the performance of activities that involve high levels of risk and expertise, such as artistic performances, surgery, or rock climbing (Csikszentmihalyi, 2000) though it

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may also occur during more mundane activities. It involves completely focused motivation and single-minded immersion sometimes to the point that the person may ignore needs for sleep and food. Thus, the term flow (and certain mystical experiences that are associated with it such as self-transcendence) is often associated with intense and even mystical feelings, and, by some views, may be open only to people of certain personality types (though see Engeser, 2012, and especially, Engeser & Schiepe-Tiske, 2012; Keller & Landhauber, 2012). We view flow as being on a continuum with the feeling of being in the zone – the feeling state that we investigate in the present experiments. In the review of the literature that follows, we use the term ''feeling in the zone'' to refer to both types of experiences.

1.1. The balance hypothesis

Keller and Bless (2008) conducted an exhaustive literature search and found that only two experimental studies of feeling in the zone had been published up to that point (Mannell & Bradley, 1986; Rheinberg & Vollmeyer, 2003; see also Moller, Meier, & Wall, 2010). The first of these studies (Mannell & Bradley, 1986) established that people were more likely to feel in the zone when they were given clear rather than ambiguous instructions about how to complete an experimental task. The second study (Rheinberg & Vollmeyer, 2003), which is more directly relevant to the present research, tested a theory from the non-experimental literature known as the *balance hypothesis*. The balance hypothesis stipulates that zone states arise when the perceived level of demand posed by a task matches a person's perceived ability or skills for completing the task (Csikszentmihalyi, 2000). That is, zone states are believed to arise only when perceived task demands do not exceed perceived ability (i.e., when the task does not seem too difficult) and when perceived ability does not exceed perceived demands (i.e., when the task does not seem too easy). The balance hypothesis is particularly interesting from a learning perspective because of its alignment with region of proximal learning (RPL) theory, which states that learning is optimized when the materials or task requirements are neither too easy nor too difficult for the particular learner (Kornell & Metcalfe, 2006; Metcalfe, 2002, 2009, 2011; Metcalfe & Kornell, 2003, 2005). The idea that there is a sweet spot for learning that is just slightly beyond what the learner has already mastered is also consistent with the theoretical views of Piaget (1952), Berlyne (1966) and Atkinson (1972). It is therefore not surprising that a number of researchers have looked at the implications of feeling in the zone for intrinsic motivation and learning (e.g., Chan & Ahern, 1999; Keller et al., 2011; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003).

Rheinberg and Vollmeyer (2003) tested the balance hypothesis by having participants play a computer game that varied in its level of difficulty across trials. Their assumption was that each participant's ability would remain constant throughout the experiment, but that perceived challenge would vary in accordance with the difficulty level of each trial, that is, as a function of the task demands. Because they presumably designed the game so that the average participant's ability would significantly exceed the lowest difficulty level but be far surpassed by the highest difficulty level, they hypothesized that participants would experience an optimal degree of task demands and relatively high levels of zone when playing the game at medium levels of difficulty. The results of their study confirmed this hypothesis. Keller and Bless (2008) conducted a similar test of the balance hypothesis by creating three conditions of the game *Tetris*, each of which reflected a different relationship between perceived ability and task demands. In the boredom and overload conditions, objects fell either at a very slow or very fast rate that was held constant throughout the trial. In contrast, the speed of the game in the adaptive condition was automatically adjusted by the computer in order to maintain a fixed level of performance and an optimal level of task demand. More specifically, if a participant in the adaptive condition successfully completed five or more lines of the game within a particular time frame, the speed was automatically increased by one interval. But, if the player completed only three lines or less lines in the same time frame, the speed was decreased by one interval. Consistent with the balance hypothesis, the results of the study showed that participants' zone judgments were highest when the demands of the task had been matched to their ability (i.e., in the adaptive condition).

1.2. Balance-plus

Though the balance hypothesis has received some empirical support, it is limited in terms of the specificity of its predictions. First, although the notion of a balance between task demands and ability is attractive, this notion really only specifies the conditions that are likely to produce ''optimal experiences'' or feelings of zone. It cannot be used to precisely describe the degree of balance or optimality experienced by an individual at a particular point in time. Later in the paper we examine several performance variables that could potentially serve as a direct measure of optimality, including hit rate, false alarm rate, *d*', and the absolute amount of reward (i.e., successes minus failures during a fixed amount of time allotted to the task).

Another limitation of the balance hypothesis is that it is unable to explain why the zone experiences of an individual vary between trials even though the demands of the task and the individual's ability level remain constant. For instance, although most professional basketball players exhibit a consistent level of ability over the course of a season and although their level of competition remains relatively stable, they often report feeling more or less in the zone from one game to the next. Research by Gilovich, Vallone, and Tversky (1985) on the hot hand phenomenon suggests that this variability in players' zone experiences may be due to the manner in which they interpret random fluctuations in their performance. That is, when players make a substantially higher percentage of baskets during a game than their season average would seem to predict (or make what incorrectly seems to be an improbable string of consecutive baskets; Gilovich et al., 1985), they often report the feeling of having a "hot hand" and being-in-the-zone. Conversely, when they make what seems like an improbably low percentage of baskets, they report feeling "cold" and being in a slump.

We suggest that the balance factor may be augmented by another, metacognitive, factor: higher levels of zone may be experienced when *perceived* performance on a particular trial is high compared to when it is low. We call this the balance-plus hypothesis. It is important to note that this hypothesis is silent as to the sources of variation in an individual's perceived performance between trials. That is, regardless of whether this variation is due to a sudden change in the individual's motivation to complete the task, to randomness in her movements, to feelings of fluency or disfluency, or to illusory performance monitoring, it should contribute to her overall feeling of being in or out of the zone.

An important implication of the balance-plus hypothesis is that, because zone states are considered to be intrinsically rewarding (Keller & Bless, 2008; Privette, 1983), people may be particularly motivated to continue engaging in tasks that provide an optimal degree of task demands (i.e., tasks that either match or slightly exceed their current abilities) while simultaneously affording the perception of unusually high levels of performance. That is, similar to how the effects of perceived performance on a basketball player's shot selection are mediated by feelings of hotness (such that players who believe they are hot are likely to take more shots than players who believe they are cold), we predict that there is an effect of balance-plus on people's motivation to continue or repeat the current task that is mediated by their zone experiences. In Experiment 1 we investigate the underlying determinants of feeling in the zone, as characterized by the balance plus hypothesis. In Experiment 2 we will turn to motivational implications.

2. Experiment 1

To investigate the cognitive antecedents of the feeling of being-in-the-zone, we adapted a computer game previously used to study people's metacognitive judgments of agency (see Metcalfe, Eich, & Castel, 2010; Metcalfe, Eich, & Miele, 2013; Metcalfe & Greene, 2007; Metcalfe, Van Snellenberg, DeRosse, Balsam, & Malhotra, 2012; Miele, Wager, Mitchell, & Metcalfe, 2011). In the game, participants were tasked with moving the cursor in order to catch Xs and avoid Os as they scrolled down the screen. The level of task demand posed by the game was manipulated within-participants by varying the speed with which the Xs and Os moved during each 20-second trial (Metcalfe & Greene, 2007). In Experiment 1, we asked participants to make zone judgments and judgments of performance (JOPs) after each trial. Consistent with the original balance hypothesis, we predicted that participants' experience of zone would probably be stronger after playing the game at moderate speeds than after playing the game at either very low or very high speeds. Although we evaluated speed directly, we particularly sought to identify a measure of performance that would be optimized at moderate speeds and correlated with participants self-reported zone judgments. Such a measure could serve as a proxy for the balance between ability and task demand and could be used to determine whether the effect of balance on zone was moderated by participants' perceived performance, such that the highest levels of zone were reported when participants' perceived themselves to have performed especially well at a high (but not exceedingly high) speed.

2.1. Method

2.1.1. Participants

The sample of 20 participants included students from Columbia University and community volunteers from Austin, Texas. Two participants were missing data from at least one full block of trials and another participant was exposed to fewer stimuli on each trial due to a computer error. Data from these three participants were excluded, leaving data from 17 participants (33% female, M_{age} = 31.2 years, SD_{age} = 14.3)[1] in the analyses reported below. Participants were treated in accordance with APA regulations.

2.1.2. Materials and design

Each 20-second trial of the computer game task involved using a mouse to move a cursor along a horizontal track at the bottom of the screen as stimuli (Xs and Os) that were randomly distributed from left to right scrolled down from the top of the screen to the bottom (the total number of stimuli depended on the speed of the game; see Fig. 1). The Xs or Os disappeared as soon as they were "touched" by the cursor, but continued to scroll past the horizontal track if they were not touched. In addition, a distinctive BONK sound occurred each time an X was hit and a THUD sound occurred each time an O was hit. Seven different experimental conditions were created by manipulating the speed with which the Xs and Os scrolled down the screen. Each session included 35 trials grouped into 5 blocks, such that each block contained trials from all 7 conditions. The order of conditions within each block was randomly determined without replacement.

2.1.3. Procedure

After completing a demographic questionnaire (which included questions about their experience playing video games), participants were told that they would be playing a game in which the purpose was to use the mouse to touch the Xs when they came into range of the cursor box and to avoid touching the Os. Participants then read a brief passage about zone, which

[1] Demographic data from 8 of the 17 participants was missing due to experimenter error.

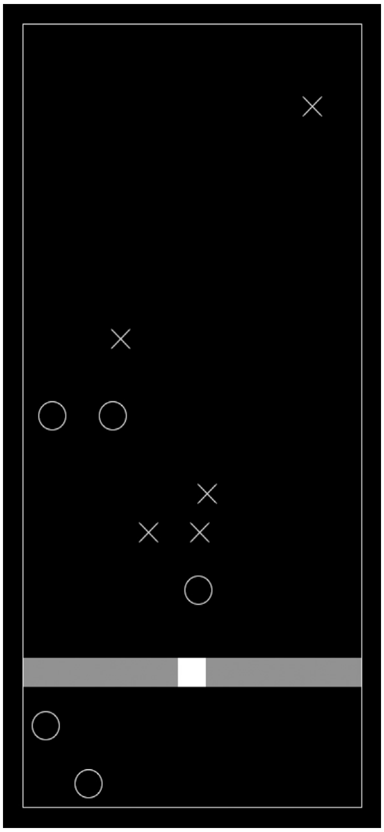

Fig. 1. Screen shot of the computer game that participants played in both experiments.

we called "Z-factor", that included descriptions of flow (Csikszentmihalyi, 2000) and hot hand (Gilovich et al., 1985), as well as a quote from the soccer player Pelé (Pelé & Fish, 2007):

> In sports it may be known as "being on fire" or in music it may be known as "being in the groove," but there exists a specific feeling in which everything seems to flow in a way that feels like everything is going your way. From sports stars to musicians to video game players, this feeling of being "in the zone" has several key components that may elucidate this state though not all are needed at any one time.

- High degree of concentration and focus on a limited field of attention
- Loss of the feeling of self-consciousness, the merging of action and awareness and absorption in the activity
- Distorted sense of time – one's subjective experience of time is altered
- Sense of personal control over the situation or activity
- The activity is intrinsically rewarding, so there is an effortlessness of action

> The legendary soccer player Pelé described his experience as feeling "...a strange calmness... a kind of euphoria. I felt I could run all day without tiring, that I could dribble through any of their team or all of them, that I could almost pass through them physically."
> For the purposes of this exercise, we will call this feeling, this state of being "in the zone", the Z-factor and will ask you periodically to rate your judgment of how much of this feeling you had during certain courses of this exercise.

Following a practice trial, participants completed the 5 blocks of experimental trials. After each trial, they were asked to make both zone judgments and judgments of performance (JOPs). For zone, participants were presented with a visual analogue scale labeled "Z-factor" and were asked to pull the slider toward the left end if the amount of zone they experienced was "none" or to the right end if the amount they experienced was "substantial." For performance, they were presented with a scale labeled "Performance" and were instructed to pull the slider to the left end if they felt that they had gotten "none correct" or to the right end if they felt they were "completely correct." In between each block of trials, participants completed a 20-second distractor task that involved subtracting by 3's from a randomly presented three-digit number.

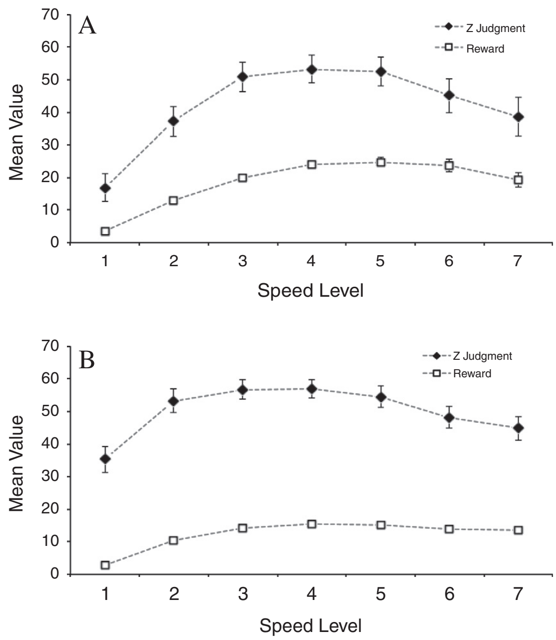

Fig. 2. Mean of each participant's mean zone judgment and mean reward by game speed for Experiment 1 (A) and Experiment 2 (B). Error bars represent standard errors of the mean.

2.2. Results

2.2.1. Zone judgments

We submitted participants' mean zone judgments to a repeated measures ANOVA with speed as the independent variable. A comparison of within-subjects contrasts demonstrated that the quadratic effect of speed was substantially larger than the linear effect, $F(1,16) = 62.87$, $p < .001$, $\eta_p^2 = .80$ (compared to $\eta_p^2 = .37$). That is, consistent with the balance hypothesis, participants' zone judgments were highest when the speed of the game was not exceedingly easy or exceedingly difficult (see Fig. 2a).[2]

2.2.2. Performance

We endeavored to determine whether there might be a performance-related variable that mirrored zone judgments. To examine the effect of the speed manipulation on measures of actual and perceived performance, we conducted a series of repeated-measures ANOVAs with linear and quadratic contrasts. As shown in Table 1, the linear effect of speed was significantly negative (and stronger than the quadratic effect) for hit rate, $F(1,16) = 935.82$, $p < .001$, $\eta_p^2 = .98$, d', $F(1,16) = 126.32$, $p < .001$, $\eta_p^2 = .89$ (compared to $\eta_p^2 = .87$), and JOPs, $F(1,16) = 64.64$, $p < .001$, $\eta_p^2 = .80$. That is, the mean proportion of X's that participants touched on each trial, their ability to discriminate between X's and O's, as well as their judgments of performance, steadily decreased as the speed of the game increased. In contrast, the quadratic effect was somewhat stronger than the linear effect for false alarm rate, $F(1,16) = 80.64$, $p < .001$, $\eta_p^2 = .83$ (compared to $\eta_p^2 = .34$).

We also investigated a performance measure that approximates the absolute amount of 'reward' the person obtained on each trial: number of hits minus number of false alarms over each 20-s trial interval. As can be seen from Fig. 2a, when performance was assessed in this manner, the amount of 'reward' participants experienced on the moderate trials was higher

[2] To evaluate whether there were effects of the previous trial judgment on current trial zone judgment we conditionalized zone judgments based on whether the current trial was slower or faster than the previous trial. When the current trial was faster, the mean zone judgment was significantly higher (47.86) than when the current trial was slower (36.19), $t(16) = 3.79$, $p = .002$. However, given the design of the experiment, the current trial was more likely to be at an objectively fast speed when it was preceded by a slower trial rather than a faster trial, and we know from the analyses presented in the paper that fast trials generally produce more zone than slower trials (even with the curvilinear effect). So, the observed difference could be due to participants experiencing more zone at faster speeds. To test this explanation, we conditionalized on *only the trials at the middle speed* (because everyone experienced this speed after a slower trial and after a faster trial). There was no difference in zone judgments when the middle speed was faster (57.07) versus slower (52.96) than the previous trial, $t(16) = 1.13$, $p = .27$. We also conducted an analysis in which we entered the change in speed from the previous trial to the current trial (ranging from −6 to 6) as the predictor into a regression with zone judgments as the dependent variable. We conducted this analysis separately for each of the participants and then tested the resulting beta coefficients against 0. Consistent with the first analysis, the speed change coefficient was significantly positive, $ß = .26$, $t(16) = 4.16$, $p = .001$, such that more positive the change in speed from previous trial to current trial, the higher the zone judgment on the current trial. However, this same effect was only marginally significant, $ß = .09$, $t(16) = 1.92$, p = .07, when current speed was also entered as a predictor. Controlling for the actual speed of the current trial, there was little to no effect of direction of speed change on zone judgments.

Table 1

Measure	Speed Level 1	2	3	4	5	6	7
Experiment 1							
Hit Rate	.95 (.05)	.83 (.09)	.74 (.10)	.64 (.09)	.52 (.10)	.46 (.09)	.36 (.09)
False Alarm Rate	.15 (.06)	.10 (.05)	.08 (.04)	.07 (.03)	.06 (.02)	.09 (.04)	.10 (.04)
d′	1.97 (.15)	2.39 (.36)	2.19 (.42)	1.93 (.35)	1.69 (.35)	1.29 (.41)	.99 (.45)
JOPs	79.11 (17.27)	71.89 (17.09)	67.21 (17.20)	63.22 (18.16)	58.84 (17.15)	49.28 (18.89)	39.33 (23.94)
Zone Judgments	16.88 (17.20)	37.19 (18.88)	50.81 (18.56)	53.27 (18.01)	52.39 (18.11)	45.12 (21.78)	38.64 (24.54)
Reward (Hits − False Alarms)	3.65 (0.28)	13.06 (1.78)	19.95 (3.63)	23.95 (4.22)	24.74 (5.90)	23.65 (7.53)	19.27 (8.82)
Experiment 2							
Hit Rate	.95 (.10)	.85 (.08)	.70 (.10)	.58 (.08)	.48 (.09)	.41 (.07)	.37 (.06)
False Alarm Rate	.10 (.15)	.07 (.10)	.09 (.09)	.10 (.06)	.11 (.07)	.12 (.06)	.14 (.05)
d′	1.63 (.39)	2.54 (.50)	2.05 (.53)	1.61 (.43)	1.30 (.52)	1.03 (.45)	.82 (.36)
JOPs	84.81 (15.47)	73.99 (14.78)	65.09 (15.53)	56.89 (15.76)	51.86 (17.01)	43.03 (17.04)	35.01 (18.13)
Zone Judgments	35.30 (26.96)	53.18 (24.01)	56.73 (20.04)	56.81 (19.15)	54.51 (22.45)	48.19 (22.63)	44.79 (25.09)
Reward (Hits − False Alarms)	2.76 (.70)	10.55 (2.08)	14.09 (3.66)	15.43 (3.79)	15.03 (5.80)	14.03 (5.42)	13.55 (3.78)

Note: Values represent means, followed by standard deviations which are in parentheses.

than what they experienced on the easy or difficulty trials, mirroring the results observed with the zone judgments. As before, we submitted this measure to a repeated measures ANOVA with speed as the independent variable. The pattern of results was the same as in the previous analysis of zone judgments. That is, the quadratic effect of speed was substantially larger than the linear effect, $F(1,16) = 338.84$, $p < .001$, $\eta_p{}^2 = .96$ (compared to $\eta_p{}^2 = .77$), such that participants experienced the highest levels of reward when the game was not too easy or too difficult (i.e., when there were a lot of X's, but they did not scroll down the screen too fast to be touched).

Next, to examine whether there was a strong within-subjects association between reward and zone judgments, we computed Pearson product-moment correlation coefficients (r) for each participant and then submitted them to a one-sample t-test. The results of the test show that the mean correlation (.65) was significantly greater than zero, $t(16) = 15.37$, $p < .001$.

2.2.3. Balance-plus hypothesis

Next, we looked to see if participants' JOPs still predicted their zone judgments after controlling for reward (which can be interpreted as a proxy for balance) and actual performance. To accomplish this, we followed procedures proposed by Lorch and Myers (1990) and Cohen, Cohen, West, and Aiken (2002) for conducting regression analyses of repeated measures data. First, we submitted each participant's zone judgments to a separate hierarchical regression in which JOPs, reward (total number of hits minus false alarms), and d' were assessed in the first step, and the reward × JOP interactions was assessed in the second step. We then computed a series of one sample t-tests to determine whether the standardized beta coefficients for each predictor were significantly different from zero. Consistent with the original balance hypothesis (Keller & Bless, 2008; Rheinberg & Vollmeyer, 2003) and with the correlation analysis above, the main effect of reward on zone judgments was significant, $\bar{\beta} = .67$, $t(16) = 13.55$, $p < .001$, whereas the effect of d' was not, $\bar{\beta} = -05$, $t(17) = -.83$, $p = .42$. This reflects the fact that zone judgments were highest when reward was maximized (i.e., at moderate speeds). Importantly, there was also a significant main effect of judgments of performance, $\bar{\beta} = .31$, $t(16) = 3.41$, $p = .004$, such that participants' feelings of being in the zone were related to their perceptions of how well they had performed, even when controlling for the amount of reward they experienced, as well as how well they had actually performed (see Fig. 3a).

In addition, the main effects of 'reward' and JOPs were qualified by a significant interaction, $\bar{\beta} = .16$, $t(16) = 2.98$, $p = .009$. This interaction is depicted in Fig. 4a. Note that, for purposes of illustration, mean zone judgments in the figure were estimated at 1 *SD* above (high) and below (low) the mean JOP, as well as 1 *SD* above (high) and below (low) the mean reward, for each participant. Follow-up analyses showed that at high levels of reward (1 *SD* above the mean), there was a strong positive association between perceived performance and zone judgments, $\bar{\beta} = .52$, $t(16) = 4.79$, $p < .001$. At low levels of reward (1 *SD* below the mean), the association was weaker, though still at significance, $\bar{\beta} = .22$, $t(16) = 2.11$, $p = .05$. Thus, consistent with the balance-plus hypothesis, it appears that the positive effect that completing a rewarding and sufficiently challenging task has on one's zone experience is magnified by increases in perceived performance.

2.2.4. Discussion

Consistent with the original balance hypothesis, which posits that the experience of zone is strongest when the task demands match one's ability to complete it, the results showed that participants' zone judgments were higher after playing the game at moderate speeds (when their absolute level of reward was maximized) than after playing the game at an undemanding or (to a lesser extent) an exceedingly difficult speed (when their absolute level of reward was low). However, this effect was moderated by participants' changing *perceptions* of their own performance. That is, when the task was sufficiently challenging (i.e., at moderate and high speeds), participants' already strong feelings of zone were further magnified by increases in perceived performance; but, when the task was undemanding, participants' relatively weak feelings of zone

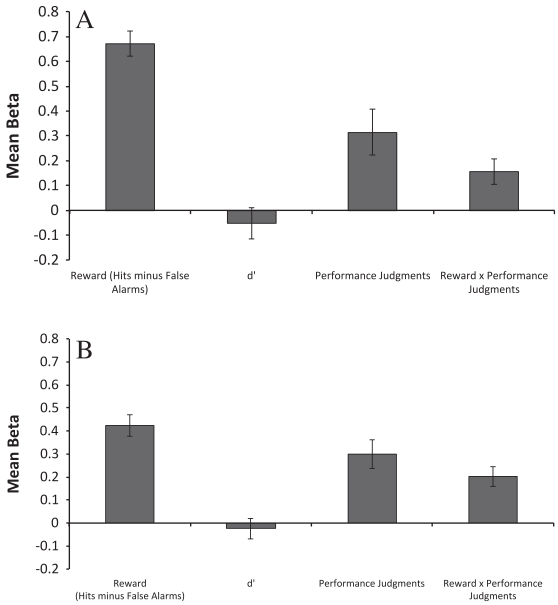

Fig. 3. Mean beta coefficients from within-subject hierarchical regression analyses in which zone judgments were regressed onto reward, *d*', and JOPs in the first step, and the reward × JOP interaction in the second step for Experiment 1 (A) and Experiment 2 (B). Error bars represent standard errors of the mean.

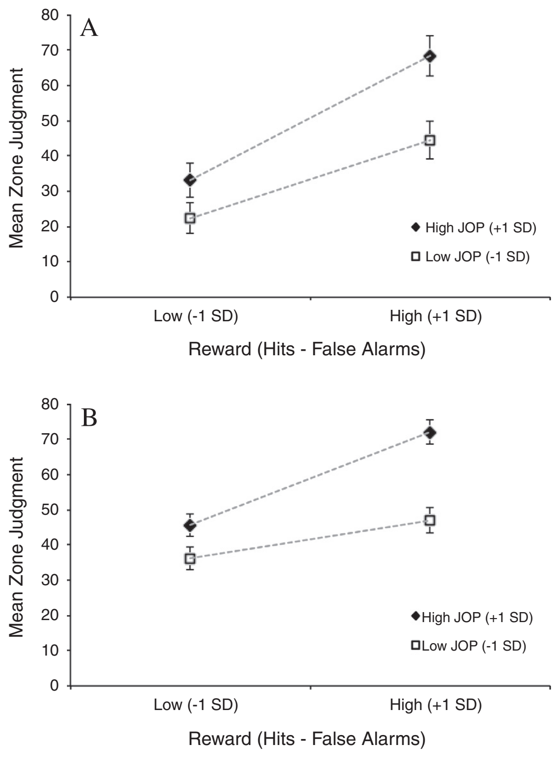

Fig. 4. Mean zone judgments by reward and perceived performance for Experiment 1 (A) and Experiment 2 (B). Zone judgments were estimated at 1 *SD* above (high) and below (low) the mean reward, as well as 1 *SD* above (high) and below (low) the mean JOP, for each participant. These estimates were then averaged across participants. Error bars represent standard errors of the mean.

were less affected by perceived performance. Thus, just as hitting a series of shots during intense competition leads basketball players to believe they have the "hot hand", the *perception of performing* well at a challenging computer game can lead people to feel that they are in-the-zone. Additional support for this conclusion comes from a second experiment in which we investigated whether the combination of balance plus perceived performance not only predicts people's zone experiences but also affects their preferences and behavior.

3. Experiment 2

As in the previous experiment, participants played a game in which they had to catch Xs and avoid Os as they scrolled down the screen. After each trial of the game, we asked participants to make zone judgments and JOPs. Unlike in the previous experiment, we included two different types of trials: *computer-selected* trials in which the speed of the game was randomly determined by the computer and *self-selected* trials in which the speed was determined by the participant. Each computer-selected trial was always followed by a self-selected trial. Consistent with the balance-plus hypothesis, we endeavored first to determine whether both reward optimization and perceived performance would influence participants' zone judgments on the computer-selected trials. However, in addition, we sought to determine whether participants' feelings of being in the zone would affect the speed they chose for the self-selected trials. We expected participants to choose speeds that were associated with high zone judgments on previous computer-selected trials. That is, participants should increase the speed of current computer-determined trial if the previous trial had been slow, and should decrease the speed if the previous trial had been fast; resulting, overall, in a convergence at or near the speed that maximized their zone judgments.

3.1. Method

3.1.1. Participants

The sample included 50 undergraduate students from Columbia University. Four participants indicated on the post-experiment survey that they had not fully understood the instructions or had not fully complied with the instructions and one participant confused X's with O's. Data from these participants were excluded, leaving data from 45 participants for analysis (65% female, M_{age} = 22.1 years, SD_{age} = 5.3, age and gender data was either missing or unreported for 5 participants). Compensation was $5 for approximately 30 min of participation. Participants were treated in accordance with APA regulations.

3.1.2. Materials and design

The 56 15-s trials in each session were grouped into 4 blocks. Each block included seven computer-selected trials corresponding to the seven speed conditions (which were the same as in Experiment 1).[3] The order of these trials was randomly assigned at the beginning of the block. After participants completed each of the computer-selected trials, they were asked to choose the speed for the subsequent self-selected trial by pressing an up arrow to increase the speed, a down arrow to decrease the speed, or the spacebar to keep the speed the same.

3.1.3. Procedure

Following a demographic questionnaire, participants read an abbreviated version of the passage describing zone, which we again called Z-factor. Participants were then told about the nature of the game and given an opportunity to practice a computer-selected trial. Participants were also told that after some trials, they would be asked if they wanted to change the speed of the game for the subsequent trial. These instructions were followed by a brief tutorial which guided them through the process of changing speeds. Throughout the tutorial the participants were exposed to all seven of the speed conditions. Once the tutorial was over, they practiced a computer-selected and a self-selected trial back to back. After each of the trials, they practiced making zone judgments and JOPs (using the scales from Experiment 1). Participants then completed the 4 blocks of experimental trials, this time without any breaks in between blocks. Upon completing the experiment, participants were asked to complete a brief survey that included questions about their experience playing the game and their video game background.

3.1.4. Results

In this section, we first report the replication of the Experiment 1 results before turning to the question of primary interest, which is whether the feeling of being in the zone influenced participants choice of speeds.

3.1.5. Zone judgments

We first submitted participants' zone judgments on the computer-selected trials (for which the individual exercised no control over speed) to a repeated measures ANOVA with speed as the independent variable. As in the previous experiment, a comparison of within-subjects contrasts demonstrated that the quadratic effect of speed was substantially larger than the linear

[3] Data from three computer-selected trials and three self-selected trials were missing from the final block for one participant. Data from the final self-selected trial were missing for another participant.

effect, $F(1,44) = 48.20$, $p < .001$, $\eta_p^2 = .52$ (compared to $\eta_p^2 = .01$). That is, consistent with the balance hypothesis, participants' zone judgments were highest when the speed of the game was not exceedingly easy or exceedingly difficult (see Fig. 2b).

3.1.6. Performance

To examine the effect of the speed manipulation on measures of actual and perceived performance for computer-selected trials, we conducted a series of repeated-measures ANOVAs with linear and quadratic contrasts. As shown in Table 1, the linear effect of speed was stronger than the quadratic effect for hit rate, $F(1,44) = 2123.09$, $p < .001$, $\eta_p^2 = .98$, false alarm rate, $F(1,44) = 7.61$, $p = .008$, $\eta_p^2 = .15$, d', $F(1,44) = 428.21$, $p < .001$, $\eta_p^2 = .91$, and JOPs, $F(1,44) = 175.44$, $p < .001$, $\eta_p^2 = .80$.

Once again, we also investigated the absolute amount of 'reward' participants obtained on each trial (i.e., number of hits minus number of false alarms). A repeated measures ANOVA showed a similar pattern of results to the previous analysis of zone judgments. That is, the quadratic effect of speed was substantially larger than the linear effect, $F(1,44) = 265.25$, $p < .001$, $\eta_p^2 = .86$ (compared to $\eta_p^2 = .73$), such that participants experienced the highest level of reward when the speed of the game was not too easy or too difficult (see Fig. 2b).

Next, we examined whether there was a strong within-participants association between reward and zone judgments by computing correlation coefficients (r) for each participant and then submitted them to a one-sample t-test. The results of the test showed that the mean correlation (.36) was significantly greater than zero, $t(44) = 6.86$, $p < .001$.

3.1.7. Balance-plus

Next, we looked to see if participants' JOPs still predicted their zone judgments after controlling for reward (which can be interpreted as a proxy for balance) and actual performance. As in Experiment 1, we followed procedures proposed by Lorch and Myers (1990) and Cohen et al. (2002) for conducting regression analyses of repeated measures data. First, we submitted each participant's zone judgments to a separate hierarchical regression in which JOPs, reward (total number of hits minus false alarms), and d' were assessed in the first step, and the reward $\times$ JOP interactions was assessed in the second step. We then computed a series of one sample t-tests to determine whether the standardized beta coefficients for each predictor were significantly different from zero. Consistent with the original balance hypothesis (Keller & Bless, 2008; Rheinberg & Vollmeyer, 2003) and with the correlation analysis above, the main effect of reward on zone judgments was significant, $\bar{\beta} = .42$, $t(44) = 9.09$, $p < .001$, whereas the effect of d' was not, $\bar{\beta} = -03$, $t(44) = -.55$, $p = .58$. This reflects the fact that zone judgments were highest when reward was maximized (i.e., at moderate speeds). Importantly, there was also a significant main effect of JOPs, $\bar{\beta} = .30$, $t(44) = 4.71$, $p < .001$, such that participants' feelings of being in the zone were related to their perceptions of how well they had performed, even when controlling for the amount of reward they experienced, as well as how well they had actually performed (see Fig. 3b).

In addition, the main effects of reward and JOPs were qualified by a significant interaction, $\bar{\beta} = .20$, $t(44) = 4.72$, $p < .001$. This interaction is depicted in Fig. 4b. Note that, for purposes of illustration, mean zone judgments in the figure were estimated at 1 *SD* above (high) and below (low) the mean JOP, as well as 1 *SD* above (high) and below (low) the mean reward, for each participant. Follow-up analyses showed that at high levels of reward (1 *SD* above the mean), there was a strong positive association between perceived performance and zone judgments, $\bar{\beta} = .59$, $t(44) = 6.68$, $p < .001$. At low levels of reward (1 *SD* below the mean), the association was weaker, but still significant, $\bar{\beta} = .22$, $t(44) = 3.35$, $p = .002$. Thus, consistent with the balance-plus hypothesis, it appears that the positive effect that completing a rewarding and sufficiently challenging task has on one's zone experience is magnified by increases in perceived performance.

3.1.8. Speed selection

The central prediction of this experiment was that, on the self-selected trials, participants would prefer to play the game at speeds associated with high levels of zone. To test this prediction, we first coded participants' speed choices in terms of how much the speed of each self-selected trial deviated from the speed of the previous computer-selected trial, such that increases in speed were coded as positive values and decreases were coded as negative values (values ranged from -6 to 6). A preliminary analysis showed that this speed change variable was negatively predicted by the speed of the computer-selected trials, $\bar{\beta} = -.72$, $t(44) = -29.65$, $p < .001$. As shown in Fig. 5, when participants played the game at the slowest speed during a computer-selected trial, they significantly increased their speed on the subsequent self-selected trials ($M = 1.63$, $SE = .15$), $t(44) = 10.90$, $p < .001$. In contrast, when they played the game at the fastest speed, they significantly deceased their speed on the subsequent trial ($M = -1.37$, $SE = .13$), $t(44) = -10.59$, $p < .001$. Finally, when they played at the middle speed, the speed they selected for the subsequent trial tended to be the same ($M = -.13$, $SE = .14$), $t(45) = -.90$, $p = .37$.

Next, to more directly test our hypothesis, we examined whether participants' zone judgments from the computer-selected trials predicted their speed choices on the subsequent self-selected trials. First, we computed the absolute value of the speed change variable used in the previous analysis, such that larger values indicated a greater deviation between the participant's speed choice and the speed of the prior computer-selected trial (values ranged from 0 to 6). We then regressed this variable onto participants' zone judgments from the computer-selected trials.[4] The results showed that zone

[4] For five participants, the range of absolute speed change only included two values. Therefore, data from these participants was excluded from any of the analyses that involved conducting within-subject linear regressions with absolute speed change as the dependent variable.

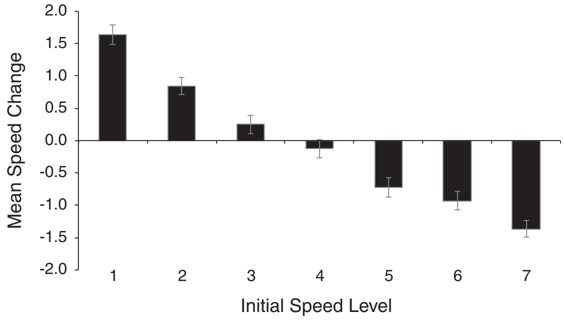

Fig. 5. Mean of each participant's mean change in speed from computer-selected trials to self-selected trials, displayed by speed level of computer-selected trials. Error bars represent standard errors of the mean.

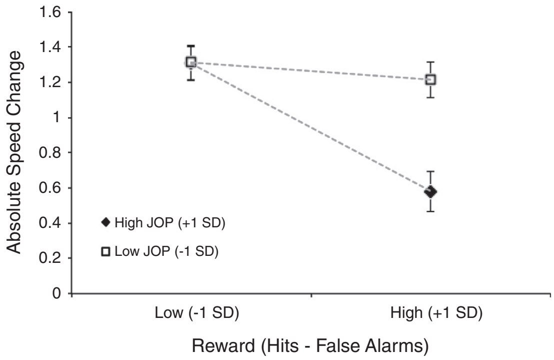

Fig. 6. Mean absolute speed change by reward and perceived performance for Experiment 2. Absolute speed change was estimated at 1 *SD* above (high) and below (low) the mean reward, as well as 1 *SD* above (high) and below (low) the mean JOP, for each participant. These estimates were then averaged across participants. Error bars represent standard errors of the mean.

judgments negatively predicted absolute speed change, $\bar{\beta} = -.32$, $t(39) = -6.05$, $p < .001$. That is, the less zone participants reported on a computer-selected trial, the more they changed their speed on the subsequent self-selected trial. Thus, it appears the participants were motivated to play the game at a speed that was likely to produce a feeling of being-in-the-zone.

Given that zone judgments appear to be influenced by the interaction between reward (as a proxy for the balance between ability and task demands) and their judgment of their own performance, we were also interested in the extent to which participants' speed choices were indirectly influenced by these variables. The results of a regression analysis (which included d', reward, perceived performance, reward $\times$ perceived performance as predictors) showed that this was indeed the case. That is, the interaction between the reward and perceived performance significantly predicted absolute speed change, $\bar{\beta} = -.19$, $t(39) = 4.65$, $p < .001$, such that the least amount of speed change was observed when both reward and perceived performance were high (see Fig. 6).[5]

3.1.9. Mediation analysis

To determine whether the effect of balance plus perceived performance on participants' speed choices was mediated by their zone judgments on the previous trials, we used the PROCESS macro (Model 8; Hayes, 2013) to estimate for each participant the indirect effect of the reward $\times$ JOP interaction through zone judgments (controlling for d'). Consistent with our general analytic approach, we then tested these indirect effects against zero with a one-sample *t*-test. The results showed that the mean indirect effect, albeit small ($-.04$), was significant, $t(39) = -2.19$, $p = .04$, suggesting that zone judgments may have partially mediated the effect of balance plus on speed change. However, the fact that the majority of the effect was not mediated by zone judgments indicates that the reward participants experienced at a particular speed directly influenced their motivation to play the game at that speed again.

[5] One potential concern with the analyses described in this section is that the range of values for the absolute speed change variable was very small for some participants. Thus, we conducted an additional set of analyses for participants who had at least four absolute speed change values across all 28 trials ($N = 31$). The effect of zone judgments on absolute speed change remained significant, $=-.36$, $t(30) = -5.51$, $p < .001$, as did the effect of reward $\times$ perceived performance, $=.21$, $t(30) = 2.60$, $p = .01$. For participants who had at least five absolute speed change values ($N = 17$), the effect of zone judgments was once again significant, $=-.31$, $t(16) = -3.38$, $p = .004$; however, the effect of reward $\times$ perceived performance was not, $=.10$, $t(16) = .80$, $p = .44$.

3.1.10. Self-enhanced zone experiences

Finally, we were also interested in determining whether participants' speed choices on the self-selected trials enhanced their zone experiences. An initial test showed that participants' zone judgments for the self-selected trials ($M = 57.66$, $SE = 2.31$) were significantly higher than their judgments for the computer selected trials ($M = 49.90$, $SE = 2.52$), $t(44) = 6.94$, $p < .001$. One potential explanation for this is that the sense of agency participants experienced on the self-selected trials after choosing a speed may have resulted in stronger feelings of zone than they experienced on the computer-selected trials when the same exact speed was selected for them. That is, the simple act of choosing a speed may have impacted participants' zone judgments over and above the speed itself. To test this possibility we computed mean zone judgments at each speed for both types of trials. Because some participants did not complete self-selected trials at all seven speeds (i.e., they chose not to play the game at very slow or very fast speeds), we decided not to submit the mean zone judgments to a repeated-measures ANOVA. Instead, we conducted separate paired-samples *t*-tests at each speed. The results of these uncorrected comparisons revealed only a significant effect at the second fastest speed, $t(34) = 2.56$, $p = .02$, such that zone judgments were higher on the self-selected trials ($M = 55.34$, $SE = 3.54$) than on the computer-selected trials ($M = 50.43$, $SE = 3.47$). There was no significant difference between trial-types for any of the other speeds (*t*s < 1.53; *p*s > .13). Thus, the main reason why participants experienced higher overall levels of zone on the self-selected trials is probably not because of a heightened sense of agency, but because they chose speeds for these trials that were likely to produce strong zone experiences.

To test this alternate explanation, we computed the difference between participants' zone judgments for each pair of computer- and self-selected trials, such that a positive number indicated a higher zone judgment on a particular self-selected trial compared to the previous computer-selected trial. We then submitted this measure to a regression analysis with absolute speed change as the sole predictor. The results revealed a significant positive association between the two variables, $\bar{\beta} = .23$, $t(44) = 4.94$, $p < .001$, such that increases in absolute speed change resulted in higher levels of self-reported zone on self-selected trials. Thus, it appears that by changing the speed of the game from the computer-selected to the self-selected trials, participants increased their feelings of being-in-the-zone.

3.2. Discussion of Experiment 2

The results of Experiment 2 strengthened support for the balance-plus hypothesis. Once again, not only were zone judgments highest after playing the game at intermediate as opposed to very high or very low speeds (neither of which optimized the absolute amount of reward experienced on a particular trial), this effect was magnified by within-participant increases in perceived performance.

In addition to predicting participants' zone judgments, the balance of task demands and ability modulated by perceived performance also predicted an important behavioral concomitant of zone: the speed participants selected for the task. That is, consistent with past research suggesting that feelings of being-in-the-zone are intrinsically pleasurable (e.g., Keller & Bless, 2008), participants' were less likely to change the speed of the game when the current speed was consistent with their peak reward experience. This effect appears to be partially mediated by participants' prior zone judgments. Furthermore, when participants' did change speeds, they tended to report higher levels of zone on that trial of the game than on the previous trial.

4. General discussion

In the present article, we examined both the cognitive antecedents and motivational consequences of the feeling of being-in-the-zone. The results of two experiments provided support for the original balance hypothesis. This hypothesis suggests that the experience of zone (like reward) is strongest when the perceived level of task demands matches a person's perceived ability or aptitude for completing it. However, as discussed in the Introduction, this hypothesis is unable to explain why the zone experiences of an individual tend to vary between trials even when the demands of the task and the individual's ability level remain constant. We have argued (based on the hot hand literature; Gilovich et al., 1985) that intra-individual variation in people's zone experiences may be due to differences in how they perceive their own performance between trials, regardless of what the source of these differences happens to be (e.g., sudden changes in an individual's motivation to complete the task, randomness in her movements, or inaccurate performance monitoring). This as well as findings from the present studies led us to propose the balance-plus hypothesis, which posits that the balance between ability and task demands (which was here operationalized in terms of reward) results in higher levels of zone when *perceived performance* on a particular trial is high compared to when it is low. The results of both experiments showed that when the task was sufficiently rewarding (i.e., at moderate and high speeds), participants' already-strong feelings of being-in-the-zone were further magnified by trial-specific increases in perceived performance. Thus, just as a random streak of consecutive made shots that the individual perceives as being better than expected can lead professional basketball players to believe they have the "hot hand", the perception of performing well on a difficult level of a computer game can augment people's feelings that they are in-the-zone.

In addition to identifying factors (such as reward and perceived performance) that impact self-reported zone experiences, we showed (in Experiment 2) that these factors also predict the speed at which participants choose to play the game. More specifically, when given the opportunity to select the speed of the next trial, participants tended to choose speeds that maximized the combination of reward and perceived performance (see Fig. 6). This effect appears to have been partially mediated by participants' zone experiences, such that the interaction of reward and perceived performance on computer-selected trials was positively associated with participants' zone judgments for those trials, which in turn were negatively associated with how much they chose to increase or decrease the speed of the game on the subsequent self-selected trials. However, it should be noted that most of the effect of reward $\times$ perceived performance on participants' speed choices was not mediated by their previous zone experiences. This is not particularly surprising when you consider that the experience of reward is an inherently motivating state.

To the best of our knowledge, Experiment 2 is the first study using a within-participants experimental design to demonstrate that the experience of zone has motivational effects on behavior. Although previous studies (e.g., Engeser & Rheinberg, 2008) have shown an association between self-report measures of zone and behavioral measures of motivation, such as task persistence or performance, both measures have typically been collected during the same performance trial. Thus, it is impossible in these studies to rule out the possibility that certain behaviors, such as increased task persistence, actually lead people to experience and report higher levels of zone, and not vice versa. A recent study by Keller, Ringelhan, and Blomann (2011) addressed this concern by showing that participants who completed a computerized knowledge task in the fit (i.e., high zone) condition were more likely than participants who completed it in the boredom and overload (i.e., low zone) conditions to return to this original task (as opposed to engaging in a new task) during a separate free choice time period. In this study (as in ours), it is not possible to explain participants' zone experiences in terms of choices that were clearly made after the experiences were over. However, unlike our experiment, the study by Keller, Ringelhan, and Blomann did not examine whether participants are sensitive to relatively small variations in their experiences of zone and reward when choosing between different levels of the *same* task.

4.1. Potential limitations

Although the findings across the two studies were consistent and supported the balance-plus hypothesis, there are two issues pertaining to the studies that should be considered further. The first issue has to do with whether the duration of the game trials (15–20 s) was long enough for participants to truly experience zone. Though the general assumption may be that zone states only emerge after people have engaged in a task for a significant amount of time (e.g., minutes as opposed to seconds; cf. Keller & Bless, 2008), anecdotal reports suggest that these states often arise immediately after the task has been initiated (Csikszentmihalyi, 2000). Furthermore, the fact that participants in our experiments were able to use the zone scale to reliably distinguish between their feelings of zone between trials suggests that changes in one's zone state do begin to emerge after a matter of seconds. That is not necessarily to say that the deepest and most intense forms of zone (e.g., flow experiences) tend to emerge this quickly. However, as discussed in the Introduction, the present article is focused on everyday forms of zone that do not require such a high level of sustained attention.

The advantage of using short game trials in our experiments was that it allowed us to collect numerous zone judgments within a single session for each participant. In previous studies (Engeser & Rheinberg, 2008; Keller & Bless, 2008), game trials were substantially longer in length (5–8 min), which greatly limited the number of zone judgments ($\leqslant$4) experimenters could collect for each participant. As a result, these studies were unable to investigate sources of within-participant variance that could potentially explain why a particular individual is likely to experience different levels of zone on the same task across moments in time. By collecting zone data from up to 56 trials per participant, we were able to manipulate features of the task and reliably detect intra-individual differences in zone experiences within a single experimental session—making it possible to directly explore the balance-plus hypothesis.

The second issue worth considering pertains to the way in which participants were allowed to change the speed of the game on self-selected trials in Experiment 2. Due to the inherent constraints of the program that we used to conduct the experiment, participants were able to change their speed to a greater extent when the speed of the previous trial was either very high or very low. For example, at the slowest speed, participants could potentially change to a new speed that was six units faster; whereas, at the absolute middle speed, participants could only change to a speed that was three units faster or slower. This means that, for analyses in which we included a measure of participants' absolute speed change for each self-selected trial, it is possible that the correlations we observed were due to measurement artifacts. For example, the significant negative correlation between participants' zone judgments on the computer-selected trials and absolute speed change on the self-selected trials could have been due to the fact that when participants' zone judgments were the lowest (i.e., at the slowest and fastest speeds), they were able to change the speed of the game the most. However, this seems unlikely considering that participants rarely chose to change from one extreme speed to another. In fact, overall, participants only changed their speed by more than three units on less than 4% of the self-selected trials. A series of analyses in which these trials were either excluded or recoded to a value of three yielded similar results to what we reported in Experiment 2, with the exception that the indirect effect reported in the mediation section was only marginally significant.

4.2. Implications for research on metacognition and learning

The present findings have implications for a number of research domains in which the experience of zone is believed to play an important role in motivating performance. Here we focus on one domain in particular, which encompasses the ways in which students strategically regulate their own learning. Recently, numerous studies (see Dunlosky & Metcalfe, 2009) have attempted to explain how students use information about the ease or difficulty of different materials to decide what they should study next. Research from our lab has shown that, in most cases, students tend to study materials that are not too difficult and not too easy; these materials are said to fall within their region of proximal learning. What prior research on zone suggests is that one reason students may prefer to allocate their study time to materials within their RPL is because these materials, by virtue of being appropriately challenging for their ability level, are the most likely to produce zone experiences (which they find intrinsically rewarding). Our present findings take the implications of zone for learning one step further by suggesting that students are particularly likely to experience high levels of zone if, while studying materials in their RPL, they perceive their efforts to be productive. That is, whether or not studying within one's RPL leads students to be particularly engaged in the material and motivates them to continue studying may depend in large part on their online metacognitive assessments of their own learning. Future research is needed to more directly explore the potential relationship between zone experiences and metacognitive judgments within the domain of self-regulated learning.

5. Conclusion

We have presented a paradigm for studying the feelings of being in the zone that people frequently experience during everyday tasks, such as playing a computer game. By collecting numerous zone judgments for each participant within a single experimental session, we were able to examine intra-individual sources of variance that explain why people often feel more or less in the zone on the same task from one moment to the next. The results of our studies provide strong support for what we have termed the balance-plus hypothesis, which posits that zone experiences are strongest and have the greatest motivational force when the balance between task demands and ability is accompanied by positive assessments of one's own performance.

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